

**Method, Computer Software Products, Client Terminal, Network  
Element and Network for Efficient Use of Network Resources by Just-  
in-Time Modulation of Quality of Service Based on Service Usage and  
5    User Behavior**

**BACKGROUND OF THE INVENTION**

**Field of the Invention**

The present invention relates to modulation of quality of service (QoS) in  
access networks. The invention is based on a priority application,  
10   EP 02360213.9, which is hereby incorporated by reference.

**Background**

Many sophisticated emerging applications, such as video streams,  
multimedia conferencing, or distributed virtual reality deploy in today's  
15   internetworking infrastructure. The main due requirement that all these  
applications share is the need for (guaranteed) quality of service (QoS) such  
as high bandwidth, delay, and jitter delay etc.

The ITU-T E.800 (08/94) recommendation introduces into the QoS concept  
20   on page 1 to 4 and defines there areas that affect the QoS. This  
recommendation describes factors that contribute collectively to the overall  
quality of service as perceived by the user of a telecommunication service.  
The user's degree of satisfaction of the quality of service can be divided into  
service performance areas like support, operability, servability, and security.  
25   It defines QoS as the collective effect of service performance which  
determines the degree of satisfaction of a user of the service.

Service providers that offer services with a guaranteed quality require management systems that can retrieve, calculate and present QoS data from the four performance areas. These management systems have to control the Service Level Agreements (SLA), between the consumers and the provider, and react on service quality violations according to business rules. Today there exist products to manage this, but no standards or de-facto standards exist to facilitate the integration of a QoS management system with other management systems such as mediation, billing and service activation as part of a total management solution.

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The QoS requirements are typically specified in terms of bounds, e.g., the worst case end-to-end delay or the maximum bandwidth. Other parameters may be specified as well.

15 On the other hand the networks have limited resources with respect to quality of service. The resources are shared between consumers.

Today the resources are allocated mainly statically by consumers, e.g. according to a business model. There are colored services (gold, silver, bronze) available, where per connection at connection set-up a static type of QoS is chosen. From telephony an optimization is known, minimizing cost by choosing a subscription-type (provider), e.g., by a call-by-call prefix or user-preferences, at subscription time. Another example is the subscription-type (billing) to user-preferences in mobile communication.

25 There is no cost reduction and no change of QoS at this moment, only billing is adapted while QoS remains.

This QoS management is of rather static type, configured administratively at subscription time. Changing the QoS and price of

the subscription is an administrative task. The granularity of this approach is limited to the connection-setup, rather than the requirements of applications that use them.

- 5 This prior art has some major disadvantages. It does not take into account the cost for operator. Effectively no change of QoS, only billing is adapted while QoS remains the same. The approaches with respect to change are limited . Typically a user can change subscription mode 2 or 3 times. And the granularity is limited to a  
10 connection, instead of services or finer granularity. The QoS adaptation is triggered by user, based on match between preferences and behavior of the service. The user has to make the matching judgement himself.
- 15 Especially today's broadband access networks lack dynamic subscription types. There are static subscription types dealing with the connection as a whole. Typically, at subscription-time, the user chooses a type gold versus bronze and this type is not changed thereafter. If the user wants to use demanding services, he or she will have to change his or her entire  
20 connectivity subscription impacting all services and all family members.

Figure 1 to Figure 5 explain the current problems and the proposed solution. For a gold service, the end-user will pay a lot of money to have, e.g. a high bandwidth available at all times, satisfying most of his needs.

- 25 Although the operator will have significant revenues, he will have to provision a lot of unused bandwidth.

For a bronze service, the end-user will have a cheap subscription that will limit the networking performance. An upgrade from bronze to gold will be expensive and will be a time-consuming administrative task.

- 5 Therefore it is necessary to provide a method for quality of service, e.g. bandwidth, allocation in an highly adaptive way.

Such a method for allocation of bandwidth in a predictive fashion is known from the international patent application WO 99/44335. There packets are  
 10 identified with particular data streams and characteristics of the data streams are used to predict probable future bandwidth requirements. Such predictions are used to allocate high-bandwidth channels and to close or switch channels as in accordance with predicted needs. Preferably the system is self-learning and can modify a rules base for making allocation  
 15 decisions e.g. based on actual use statistics.

European Patent EP 1 202 528 describes a development in the direction from a user's perspective instead of the technical view in terms of bandwidth, namely a browser-based monitoring system and method. A  
 20 browser operable with a user's Internet-compliant device is provided for launching a transaction session, wherein a media-based parametric detector is associated with the browser in order to track a plurality of media-based parameters and metrics generated during the transaction session. The media-based parameters and metrics are effectuated at least  
 25 in part due to the user's interaction with the browser with respect to the transaction session. A reporting structure is provided in association with the browser for reporting the media-based parameters and metrics to an Internet entity for effectuating an IP-based service.

European Patent Application EP 1 158 740 relates to a framework for achieving cross-adaptability by providing components for QoS management in the communication network(s) by means of a component coordinator unit and targets the uniformity problem.

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European Patent Application EP 1 021 015 discloses a network-device control system for controlling a network device by acquiring user priority or application priority and, controlling in accordance with the priority.

- 10 The article ,A CORBA-BASED QUALITY OF SERVICE MANAGEMENT FRAMEWORK FOR DISTRIBUTED MULTIMEDIA SERVICES AND APPLICATIONS' IEEE NETWORK, IEEE INC. NEW YORK, US, vol. 13, no. 2, March 1999 (1 999-03), pages 70-79, XP000875023 ISSN:0890-8044 addressed issues of QoS management services in distributed multimedia
- 15 services and applications. The article provides an end-to-end QoS management called the QoS management framework. A key component of this framework is the QoS Management Service Object, which orchestrates resources at endpoints, coordinating resource management across layer boundaries. Services such as translation, monitoring, admission, and
- 20 negotiation are provided by the QoS Management Service Object allowing dynamic negotiation and renegotiation of QoS by users.

A further method and apparatus for a variable bandwidth experience for an end-user is described in the international patent application

25 WO 01/50278.

It is a problem to provide network resources uniformly in terms of the above mentioned QoS efficiently in order to satisfy the real demand of customers, i.e. from a user's perspective instead of the technical view in terms of bandwidth, as good as possible. In order to solve this situation one has to schedule the network resources, i.e. the QoS, with respect to the requests and expectations of the users.

### **OBJECTS AND ADVANTAGES OF THE INVENTION**

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This problem is solved by a method for allocating network resources by just-in-time modulation of quality of service (QoS) comprising steps of

- recording QoS demands and resource usage,
  - predicting required QoS demands,
  - 15 - deriving and propagating QoS demands, and
  - coordinating concurrent QoS demands of a manifold of users,
- where recording QoS demand and predicting required QoS demand is based on service-usage and user-behavior acquired by recording events at a client terminal of a user as user-behavior and aggregated in a QoS user profile.

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The problem is also solved by a telecommunication network comprising a client terminal and a scheduler server, said client terminal comprising communication means for requiring and using network resources and quality of service (QoS) demands, said scheduler server comprising scheduling or dispatching means allocating network resources based on QoS demands, wherein the client terminal further comprises acquiring means for recording events of a user as user-behavior and aggregation means for aggregating user-behavior in a QoS user profile, and wherein

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the communication means comprises demanding means for demanding predicted quality of service (QoS) demands based on service-usage and said user-behavior, and wherein said scheduling or dispatching means comprises coordinating means for coordinating concurrent QoS demands of a manifold of users and evaluation and balancing means for evaluating QoS demands and balancing QoS grants based on QoS user profile comprising aggregated service-usage and user-behavior received from a client terminal.

10 The problem is further solved by a client terminal comprising communication means for requiring and using network resources and quality of service (QoS) demands, wherein the client terminal further comprises acquiring means for recording events of a user as user-behavior and aggregation means for aggregating user-behavior in a QoS user profile, and wherein the communication means comprises demanding means for demanding predicted QoS demands based on service-usage and said user-behavior.

The problem is also solved by a scheduler server comprising scheduling or dispatching means allocating network resources based on QoS demands, wherein said scheduling or dispatching means comprises coordinating means for coordinating concurrent QoS demands of a manifold of users and evaluation and balancing means for evaluating QoS demands and balancing QoS grants based on QoS user profile comprising aggregated service-usage and user-behavior received from a client terminal.

Finally, the problem is also solved by a computer software product for allocating network resources by just-in-time modulation of quality of service

(QoS), such a computer software product comprising programming means for performing the method according to claim 1.

5 The invention comprises observing resource requests and user behavior and deriving QoS demands and scheduling the network's resources in terms of QoS, accordingly. A scheduler is modulating the QoS based on service usage and user-behavior just-in-time. Modulation, here, is a varying of QoS with respect to need of QoS. From now on the term adaptation of QoS is used for QoS modulation synonymical.

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User behavior is recorded based on the individual event stream and a prediction of required resources, e.g. bandwidth, delay, etc. is performed. The resources are scheduled by the expected or predicted demand accordingly. The adaptation of the QoS might be based on an analysis of user-behavior and a synthesis stored, e.g. in a user's profile. The  
15 modification of QoS settings might be made transparent to the user. The user might be involved when increasing QoS, e.g. bandwidth temporarily, and possibly pay accordingly.

20 The invention comprises advantageous scheduling scenarios, where the modulated QoS is triggered by service selection, where the QoS is modulated predictively, and where QoS settings are transparent to the user, and where the user is involved interactively.

## 25 **OBJECTS AND ADVANTAGES OF THE INVENTION**

The invention is a method for efficient use of network resources by just-in-time modulation of quality of service (QoS) based on service-usage and



user-behavior, a QoS user profile according to defined QoS user preferences comprising the steps of

- recording events at a client terminal of a user as user-behavior,
- generating a synthesis of user-behavior into the QoS user profile,
- 5 - predicting required QoS demand based on current user behavior and QoS user profile,
- deriving and propagating QoS demands and grants, and
- co-ordination of QoS demands of a manifold of users, based on QoS demands, QoS user profiles, QoS user preferences, and available
- 10 resources.

The invention also comprises a computer software product (client- module) for efficient use of network resources by just-in-time modulation of QoS based on service-usage and user-behavior, handling QoS user profiles

15 and/or QoS user preferences at a client terminal. The Computer Software Product might derive user-behavior based on recording events for a user at a client terminal and generate a synthesis for a QoS user profile. Independently it might predict the required QoS demand based on current and recorded user-behavior and/or user QoS profile information and QoS

20 user preferences., e.g. realized by a neuronal network.

The invention further comprises a computer software product (scheduler- module) for efficient use of network resources by just-in-time modulation of QoS based on service-usage and user-behavior for evaluating, balancing,

25 and propagating the QoS demands based on resource requests, QoS user profiles, QoS user preferences, and resource availability.

The invention is furthermore a computer software product (network- element-module) for efficient use of network resources by just-in-time

modulation of QoS based on service-usage and user-behavior that serves QoS allocations and propagates QoS demands.

5 The object of the invention is furthermore for connecting a client terminal with a network comprising a QoS user profile comprising an event log reflecting resource requests and a synthesis of user behavior. The client terminal might comprise a QoS user preferences comprising defined QoS strategies for each dedicated service. The client terminal might comprise a user interface for making the on-line (real-time) modification of QoS  
10 settings transparent to the user and means for involving the user in the decision of demanding QoS.

The object of the invention is also to provide a scheduler server for efficient use of network resources by just-in-time modulation of QoS based on  
15 service-usage and user-behavior comprising scheduling or dispatching means for evaluating and balancing, the QoS demands and propagating the QoS grants based on resource requests, QoS user profiles, QoS user preferences, and resource availability.

20 The invention is also a network element for efficient use of network resources by just-in-time modulation of QoS based on service-usage and user-behavior that comprises propagating and allocating means for serving QoS grants and propagating QoS demands and QoS grants.

25 Further, the invention is a network for efficient use of network resources by just-in-time modulation of QoS based on service-usage and user-behavior comprising at least one client terminal providing QoS demands, QoS-user-profiles, and QoS-user-preferences, at least one scheduling server providing QoS grants by evaluating, balancing QoS demands with QoS

resources, and propagating the QoS demands, based on QoS user profile information and QoS user preferences, and network elements serving QoS grants and propagating QoS demands and QoS grants.

5 Accordingly, it is an object and advantage of the present invention to adapt QoS based on a fine granularity to simulate a high performance-network. The adaptation reduces costs/effort for end-users and operators by using network resources efficiently.

10 Another advantage of the present invention is that the user does not have to make the judgment about the QoS himself.

A further advantage of the present invention is that the proposed scenario has a finer granularity for QoS changes: services instead of connection,  
15 users instead of subscriber, real-time instead of only once, modulated instead of fixed.

Yet another advantage of the present invention is that end-users only pay a cheap subscription with an extra comfort service and receive a high quality  
20 user-experience, even with this moderate subscription. Operators can dimension their networks more accurately, while generating extra revenue streams from users that normally would take cheap subscriptions.

These and many other objects and advantages of the present invention will  
25 become apparent to those of ordinary skill in the art from a consideration of the drawings and ensuing description.

## BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a schematic diagram of a prior-art method for allocating network resources illustrating the problem with a Bronze QoS;

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Figure 2 is a schematic diagram of a prior-art method for allocating network resources illustrating the solution with a Gold QoS;

Figure 3 is a schematic drawing showing a use case diagram (according to The Unified Modeling Language User Guide, Booch et. al., Addison Wesley, 1999, Chapter 17) of the relationship between interacting components managing QoS resources and demands according to the invention.

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Figure 4 is a schematic diagram illustrating the invention where QoS is adaptive managed based on service selections.

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Figure 5 is a schematic diagram illustrating the invention where QoS is adaptive managed based on observation of user behavior and prediction.

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## DETAILED DESCRIPTION OF THE INVENTION

Those of ordinary skill in the art will realize that the following description of the present invention is illustrative only and is not intended to be in any way limiting. Other embodiments of the invention will readily suggest themselves to such skilled persons from an examination of the following disclosure.

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The scheduler might work according to the following rule-chain. The error-rate is measured (prediction versus user correction) and collected through the network by the QoS scheduler for all users. The profiles of the neural  
 5 networks are corrected (batch processing) through an update over the network by the QoS scheduler.

The preferences might for example comprise the following strategies each defining a granularity of scheduling:

- 10 • User demand might be an optimization that promises the user the optimal bandwidth when needed, while reducing the QoS demand when not necessary.
- Pro-actively might use the event stream to predict a demand.
- User-profile and user-population might perform a comparison revealing  
 15 that other users with similar profiles demand a guaranteed bandwidth when accessing a certain network resource. The system will/can upgrade the user experience accordingly.

Static preferences might define a service as requiring a high QoS. The user has a preference annotate dialog for marking a service demanding certain  
 20 QoS.

The invention can be used in a collaborative distributed environment. That means the scheduler functionality as well as the client functionality and  
 25 network element functionality might be realized as a distributed system. For the readers convenience the decomposition is described in a hardware centric fashion binding functionality to network nodes, i.e., hardware entities. It might be preferable to enhance certain network management

components or even to distribute components over the network as mobile agents. The shown architecture is for illustrating purposes only.